

TX-0 COMPUTER
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE 39, MASSACHUSETTS

M E M O R A N D U M

5001-30

TO: TX-0 Users
FROM: J. E. Ward
SUBJECT: Focusing Light Pen
DATE: 29 November 1960

A. Introduction

This memorandum briefly describes a new light pen which is available to TX-0 users. Features include an optical system with a focusing adjustment to control the diameter of the field-of-view (sensitive area on the scope face) between the limits of about $1/16$ - $1/3$ inch, and a shutter button to turn the pen ON and OFF. Also, the field-of-view at any focus setting is surprisingly independent of the pen-to-scope separation from zero out to 6 inches or more.

Four of these pens are being fabricated and one each will be assigned to the TX-0, TX-2, and IBM 709. User comments are solicited by the Electronic Systems Laboratory for possible future refinement of the design.

The remaining sections of the memorandum cover background information, features of the design, operation hints, and acknowledgement of sponsorship.

B. Background

In the course of adapting the TX-0/TX-2 Light Pen to operate on the IBM 704/709, the Electronic Systems Laboratory found that it was necessary to modify the simple lucite light-pipe optics to permit operation with greater pen-to-phosphor separation. The light pipe has a rather wide angular field-of-view, as represented approximately in Fig. 1(a), and the viewed area on the screen is very dependent on both the separation and the pen amplifier gain. At separations greater than an inch or so, the pen operation becomes marginal.

The IBM 780 scope unit was not designed with light-pen use in mind, and has a canted faceplate to reduce reflections, as in TV receivers. The phosphor-faceplate separation varies from $3/4 - 2"$ over the screen, and the resulting gain and field-of-view variations of the light-pipe pen were found to be unacceptable. Since remounting the faceplate of the scope unit was difficult for various reasons, it was necessary to improve the pen optics. This approach also has the advantage of making the new pen usable on any 704 or 709 scope unit.

C. New Pen Design

1. Optics

The sensitive area of the photo-transistor used in the TX-2 pen is so small that it is essentially a point receptor. Substitution of a glass double-convex lens for the light pipe makes it possible to focus light from a small area on the scope face onto the photo-transistor, even at rather large distances, and this area is a function of the lens-to-transistor spacing. Since a variable field-of-view appears to have advantages for certain purposes, it was decided to include a focusing mount for the lens in the redesign. Tests on the TX-0 (see Fig. 3) show that the field-of-view can be varied from about $1/16$ to $1/3$ inch in diameter. The measurements of Figs. 3 and 4 were made by Jan Grondstra with the aid of a program which generates a raster and counts the number of spots seen by the pen.

Interesting (and unexpected) characteristics of the new optics are that the field-of-view of the pen is independent of distance between pen and scope, and that uniform triggering of the pen FF is obtained over a surprising range of distance without gain adjustment. On the 704, for example, Clarence Feldmann's pen tracking program operated exactly the same with the pen held 20" from the scope as it did with the pen touching the faceplate. Although no exact measurements of pen signal response as a function of spot position have been made, these observations indicate that the new pen must have response-position characteristics such as those shown in Fig. 1(b). The very steep slopes on the sides of the response envelope shown would produce the constant field-of-view, and permit reliable triggering over wide gain variations. The uniformity of the field-of-view with distance is indicated in the TX-0 measurements shown in Fig. 4. The response envelope appears always to be a cylinder, with diameter determined by the focus setting.

2. Shutter

A problem sometimes encountered with the TX-0 light pen is that it can pick up stray signals from the fluorescent room lights. Also, it is sometimes difficult to move the pen into the screen to pick out one point in a complicated display without responding to adjacent points. Although the smaller field-of-view of the new

optics is a help in this regard, it was decided to include a means for controlling pen response. We were advised by C. E. Woodward, the designer of the TX-2 pen, that a switch to electrically disable the photo-transistor or preamplifier was risky because of the very low signal levels involved. Thus a physical shutter system was chosen, as described below.

3. Construction

A schematic cross-section of the pen is shown in Fig. 2.* The shaded sections form the lens barrel which has a triple 24 pitch thread and is extended $1/8$ " for each rotation. Total travel is $1\ 1/2$ inches. Numbered rings are engraved in the barrel for ease in noting and in re-setting to a desired focus, with calibration as shown in Fig. 3. Maximum field-of-view is obtained with the barrel all the way in.

The shutter is formed by a tab on the end of a cantilevered spring extending into the inside of the lens barrel. For simplicity in drawing Fig. 2, the shutter button is shown as pushing directly on the rear end of the spring at a point beyond the furthest travel of the lens barrel. Actually, the button is located nearer the front end of the pen and operates a slide bar with a tapered end which pushes the spring at the point shown in Fig. 2. The slide button will stay in either the ON or OFF position because of friction.

Because the new lens system is shorter than the light pipe it replaces, the preamplifier is farther forward in the pen body, and a tail section has been added for hand comfort in holding the pen. An indirect benefit is that the cable connector is now inside the pen body where it is protected from "diddling" and cable strains which have sometimes resulted in intermittent operation of the TX-0 pen. The tail cap includes a split insert which permits it to be assembled over the connector on the cable.

The pen preamplifier is identical with that of the TX-2 pen, and the printed circuit boards and some parts were furnished by Lincoln Laboratory.

D. Operation Hints

1. Shutter

Care should be used in holding the pen so as not to "ride the button" and inadvertently partially close the shutter, as this reduces the field-of-view in an uncontrolled manner. If this proves troublesome, positive detents may be added to the design.

2. Amplifier Gain

The photocell-optics combination in the first of the new pens has not quite as much sensitivity as the present TX-2 pen used on

* Adapted from the mechanical drawing for the pen, ESL #7849CNO05

the TX-0, perhaps due to a "hot" photocell in the latter. Proper adjustment of the amplifier gain pot with the switch in the NON-PRESET position is required before use of the new pen.

The present distance limit for pen response to a displayed point is about 6" at maximum amplifier gain setting. If necessary, additional amplifier gain can be made available by shunting a desensitizing resistor that has been placed in series with the control potentiometer, but special arrangements should be made with Prof. Dennis or John McKenzie for any such modifications. As previously noted, response at 20" has been obtained on the IBM 704.

3. Focus

Rotate the pen barrel (white lens shade) to adjust focus. Measured diameter of the field-of-view for each focus ring is shown in Fig. 3.

Pen field-of-view (and gain) can be checked and adjusted with the aid of the one-order pen-test pattern obtained by placing the number 1001 in the Live Register, the instruction 622132 (OPR+DIS+PEN+LMR+PAD+CRY) in TBR, and pushing TEST with the STEP and REPEAT switches on. This generates a sweeping diagonal line which appears in only the right half of the screen, because AC_0 and AC_1 , the most significant X-bits, are always set to ZERO by the PEN command unless the pen and/or the gun FF's have been set to ONE by "seeing" a displayed point. Since the PEN transfer occurs after the display and before the addition from the IR, the accumulator carries can propagate into AC_1 and be displayed but never into AC_0 . Thus X-values are normally restricted to the range 0 - 377.

If the pen is held over this display, every display spot that is seen will make AC_0 a ONE for the following display operation and cause the next spot to be displayed in the left half. Since the "moved" spot won't be seen by the pen, the next spot after that will appear again in the right half and the process will repeat. Thus every other spot in the field-of-view of the pen will be moved and the field-of-view will be easily visible.

This one-order program won't work after the upcoming changes in the TX-0 order code, but a test tape with a similar program operating out of memory will be available for pen checks.

4. Cable Attachment and Removal

Unscrew the knurled section at the rear of the pen - it is split lengthwise for removal from the cable. Then unscrew the tail section to expose the connector. DON'T LOSE THE PIECES!

E. Where Did the Money Come From?

Design and construction of the new pens at the Electronic Systems Laboratory was jointly supported by DSR 7849 (Contract AF-33(616)-5477 with the AF Navigation and Guidance Lab, Wright Field) and DSR 8436 (Contract AF-33(600)-40604 with the AMC, Manufacturing Methods Division, Wright Field).

Nate Bromberg and J. E. Ward have participated in the pen redesign, and Norman Darling did the mechanical layout. Jan Grondstra is now responsible for all work concerning the pen.

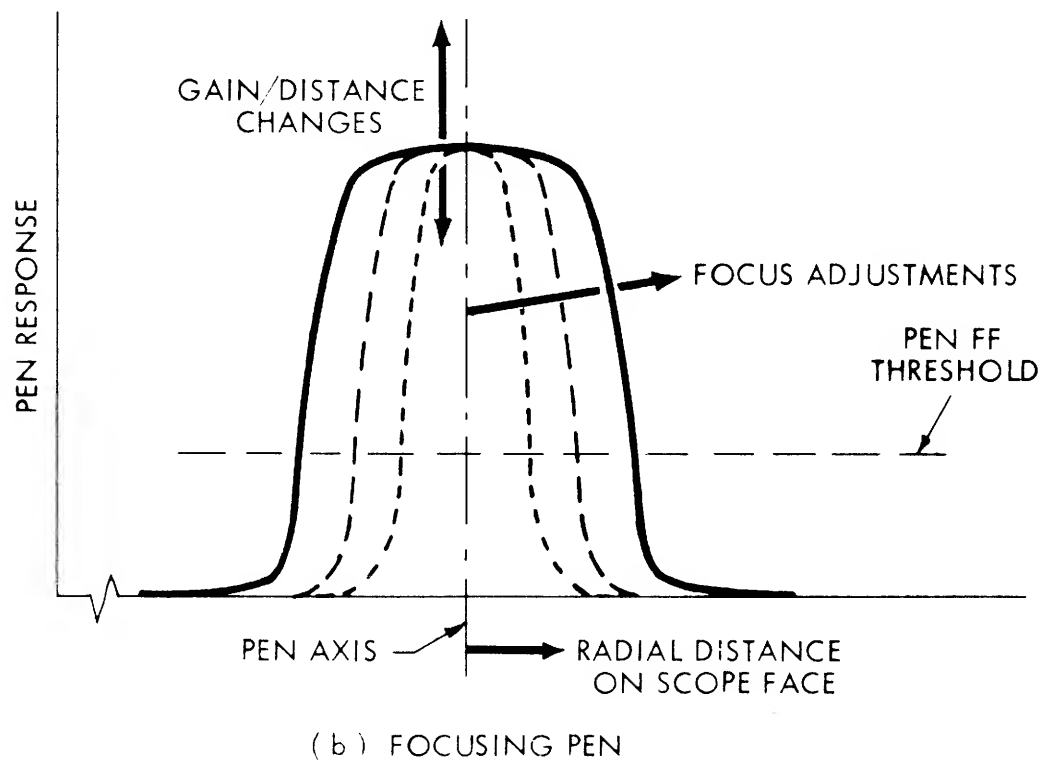
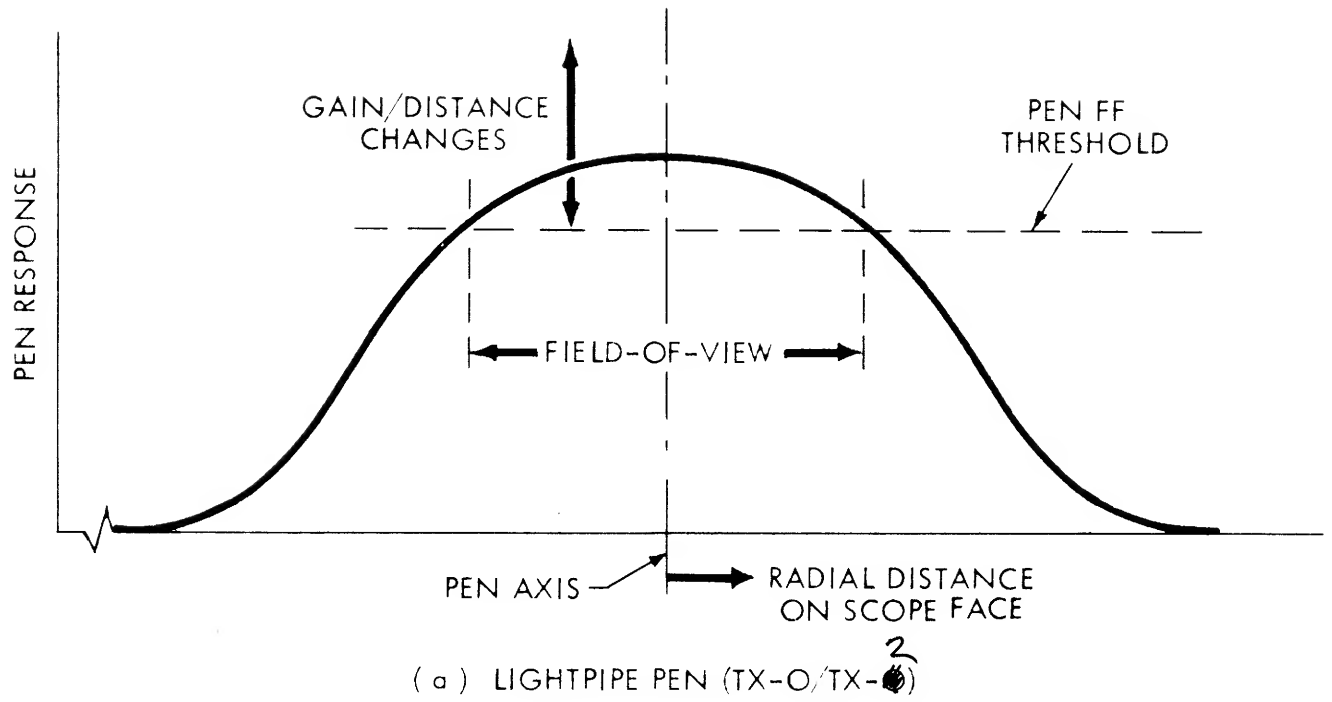


FIG. 1 APPARENT RESPONSE-POSITION CHARACTERISTICS OF LIGHT PENS

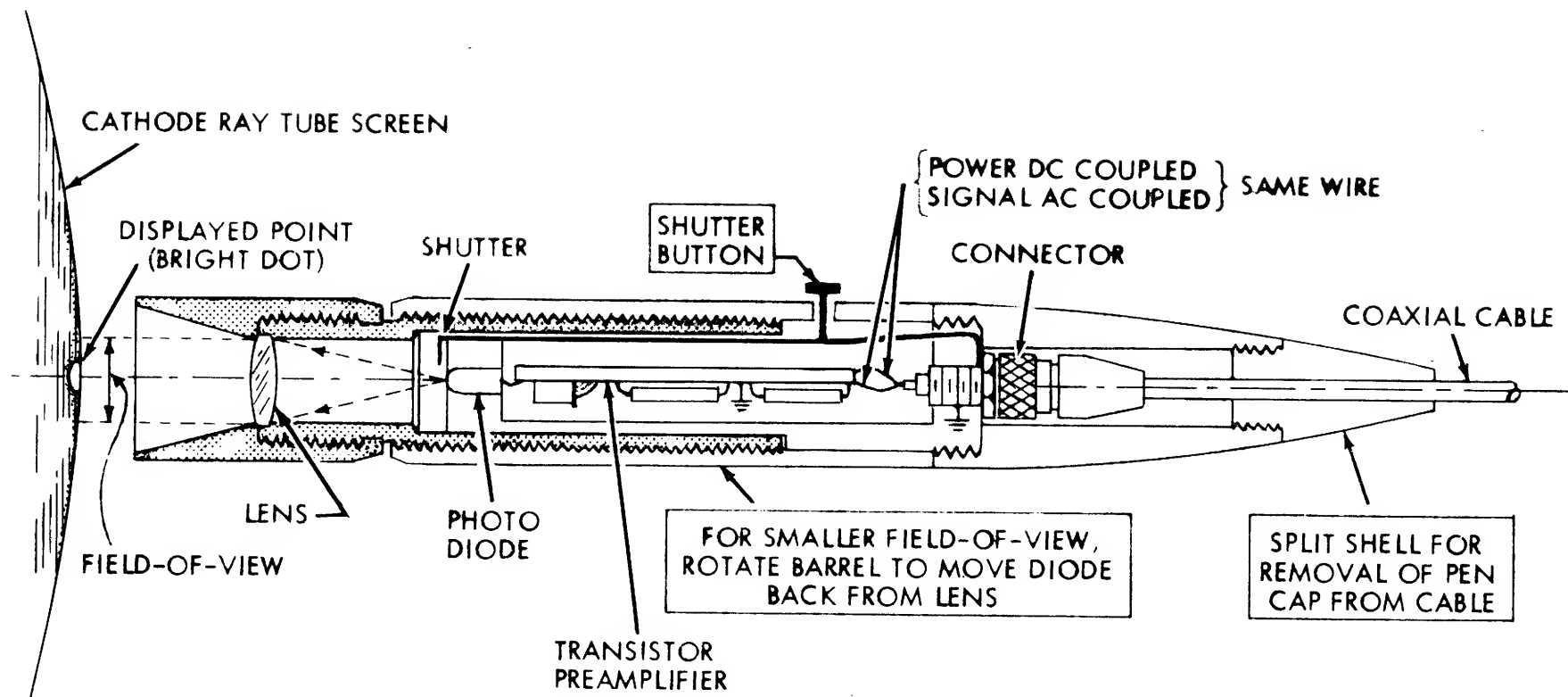


FIG. 2 SIMPLIFIED MECHANICAL LAYOUT OF FOCUSING LIGHT PEN

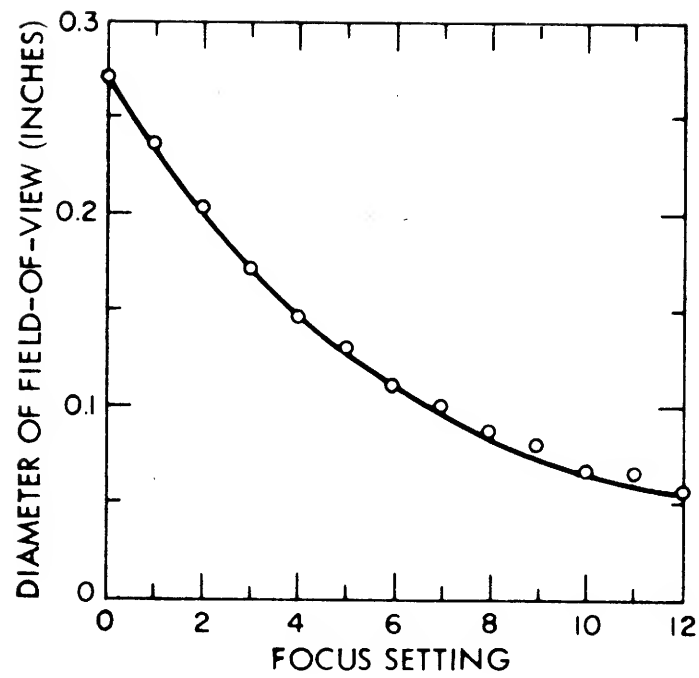


FIG. 3 FIELD-OF-VIEW AS A FUNCTION OF FOCUS SETTING

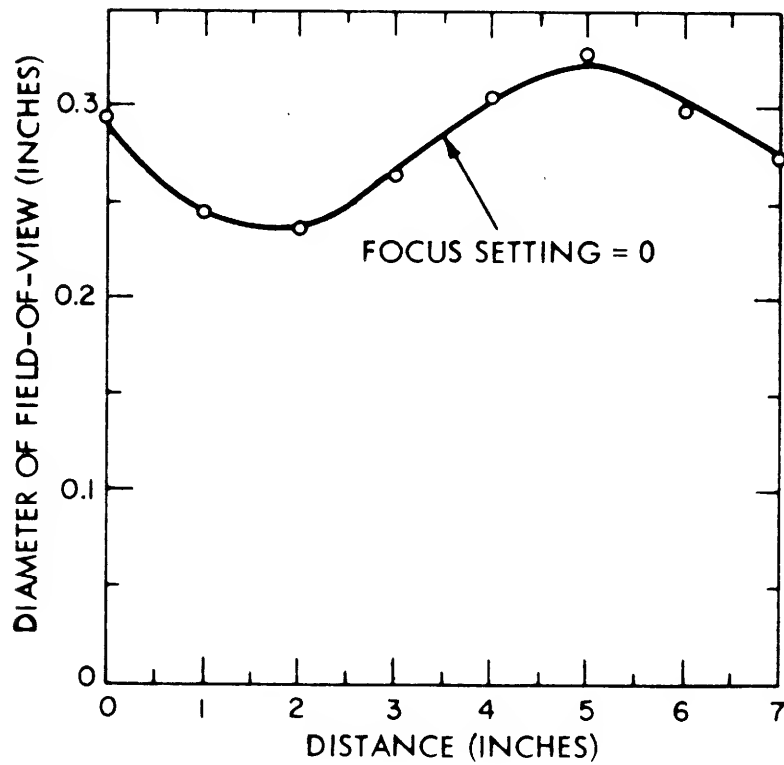


FIG 4 FIELD-OF-VIEW AS A FUNCTION OF PEN-SCOPE SEPARATION